OBSERVATIONS ON THE HOARDING BEHAVIOR OF RATS

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Bindra's (1, 2) recent demonstration that rats will hoard saccharin-sweetened food when they will not hoard the same food without the saccharin has suggested that the taste of the food may be almost as important as the chemical state of the organism [see "deficit theory" of hoarding, (5)] in influencing the onset of hoarding. Taste, however, is closely bound up with alimentation, and it might be even more significant, insofar as hoarding theory is concerned, if it should turn out that the rat's tendency to hoard is markedly influenced also by visual or tactile characteristics of the material to be hoarded. To investigate this possibility, we observed the behavior of rats in a hoarding situation in which a choice was afforded between plain pellets of Purina Laboratory Chow and pellets of the same kind wrapped in aluminum foil.

PRELIMINARY OBSERVATIONS

The rats were six littermates of the Lashley strain. We observed them frequently from the day of their birth onward. Neither during infancy nor after they were weaned at age 20 days to Laboratory Chow (available both in pellet form and as mash) was there evidence of food deprivation or unusual feeding difficulty.

At age 30 days, the rats were introduced to the hoarding apparatuses, one of which is shown in figure 1. For the next nine days (see table 1), each rat was free to explore its darkened cage, tubular alley, and illuminated cubical bin. During these nine days, we gave the rats as much food in their bins as in their cages: six plain pellets in each, daily. After the first day, four of the rats carried all their pellets to their cages; one carried only a few; and the remaining rat carried none.

OBSERVATIONS ON PREFERENCES

During the main series of observations, we continued to provide the rats with more than they could eat, keeping the cages always well supplied with plain pellets, but removing hoarded foil-covered pellets at the end of each test. The rats were permitted access to the alleys and bins only during the daily half-hour observation periods. At the beginning of each period, each bin contained 25 plain and 25 foil-covered pellets in a haphazard pile, the pellets having been placed there at the end of the test the previous evening. On the first test, rats immediately began to hoard pellets, some indiscriminately and others clearly preferring the wrapped ones.

The left-hand side of figure 2 shows the trends of the preferences during the 18 days of the main series of tests. The index of preference is based on the numbers of plain (P) and foil-wrapped (F) pellets among the first 25 pellets hoarded, or in the total hoard if fewer than 25 were taken.

$$\text{Index} = (P - F)/(P + F).$$

It is evident that five of the six rats had, or developed, marked preferences, four for foil-covered and one for plain pellets. There is no question of the statistical significances of the individual likes and dislikes.

EFFECTS OF DEPRIVATION

Between test days 18 and 39, observations were made with several hoarding materials other than Purina pellets (see table 1). Since these observations were not particularly conclusive, no other description of the results will be made than that afforded by figure 3. The observations on the influence of deprivation, however, will be mentioned.

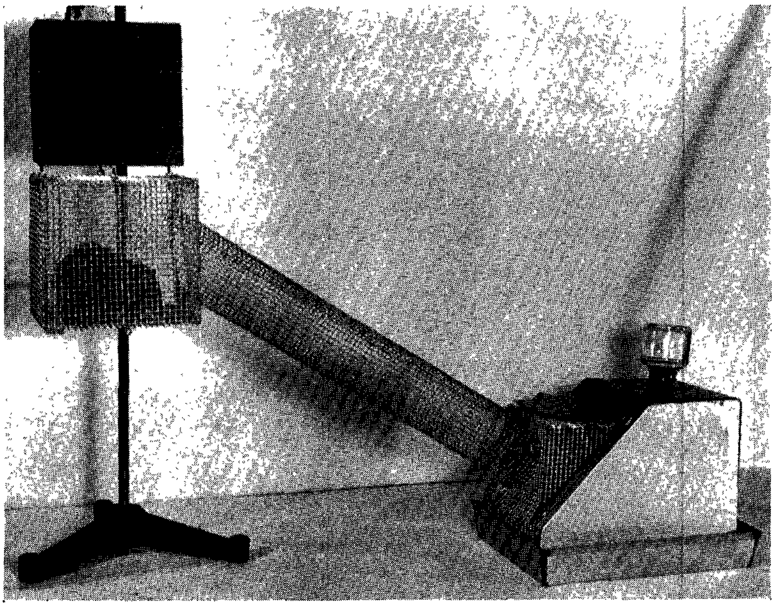

FIG. 1. HOARDING APPARATUS

The rat is in the food-bin, which is illuminated by a 60-watt light bulb in the box above it. To the right are the sloping, tubular alley and the darkened home-cage. The illumination of the bin and the darkening of the cage—both of which favor hoarding—were suggested by the observations of Stellar (6, summarized in 4). The angles of the alleys were varied from up to down to level according to a counter-balanced schedule, but no significant effect upon the behavior of the rats was noted.

From the end of the test period on the 39th day until the beginning of the test period on the 46th day, each rat was allowed only one pellet of chow a day. The average weight loss was 58 grams, 20 per cent of the pre-deprivation mean of 291 grams. On the 46th day, we resumed trials with plain and foil-covered pellets. The rats spent much of their time eating, but they hoarded, nevertheless, more than they had ever hoarded in any previous trial before deprivation (see figure 3). During the observation session the next day, after 24 hours with more pellets than they could eat, the rats ate less and hoarded more. On the third day after deprivation, they still hoarded actively.

Perhaps because deprivation had made them interested in food as food, the rats preferred the foil-covered pellets less markedly than they had earlier in the experiment. Evidently strong motivation is not always a favorable condition for the clear-cut manifestation of preference.

TABLE 1

Schedule of experimental conditions

AGE OF RATS	TEST DAYS	OPERATION OR CONDITION	SYMBOL
20		Rats weaned, transferred from maternity to stock cages	
30		Rats transferred to hoarding apparatus	
30–38		Familiarization period	
39–56	1–18	Hoarding tests with plain and foil-wrapped pellets	A
57–65	19–27	Observations discontinued	v
66–68	28–30	Hoarding tests with plain and foil-wrapped pellets	A
69–71	31–33	Hoarding tests with plain pellets, peanuts in shells, and peppermints	B
72–74	34–36	Hoarding tests with peanuts in shells, salted peanuts, and chocolates	C
75–77	37–39	Hoarding tests with plain and foil-wrapped pellets	A
78–83	40–45	Deprivation period; each rat allowed one 6-gram pellet of chow per day	d
84–86	46–48	Hoarding tests with plain and foil-wrapped pellets	A

STEREOTYPES AND PERSISTENCE OF PATTERN

Some of the rats displayed marked stereotypes in their behavior with respect to the pellets. Rat 1 always made a "dry run" on its first trip from bin to cage. Rat 2 carried each foil-covered pellet by its end, holding the aluminum-foil flap. Rat 3 often circled the bin before selecting a pellet. Rats 4, 5, and 6 went through "suspicious" phases during which they chewed some of the foil off each foil-covered pellet before carrying it to the cage. These examples indicate that the components of hoarding behavior tend to become integrated into an inflexible pattern.

Several other observations showed further that once the pattern is established, it tends to run its course even after there are no pellets left in the bin. After all the pellets (or all the preferred pellets) had been hoarded, there were many trips between bin and cage without pellets (8). On several occasions rats carried misplaced wood shavings and old bits of aluminum foil to their cages. Rats 2, 5, and 6 carried their own tails into the alleys and as far as the cages, rat 5 seven times in all.

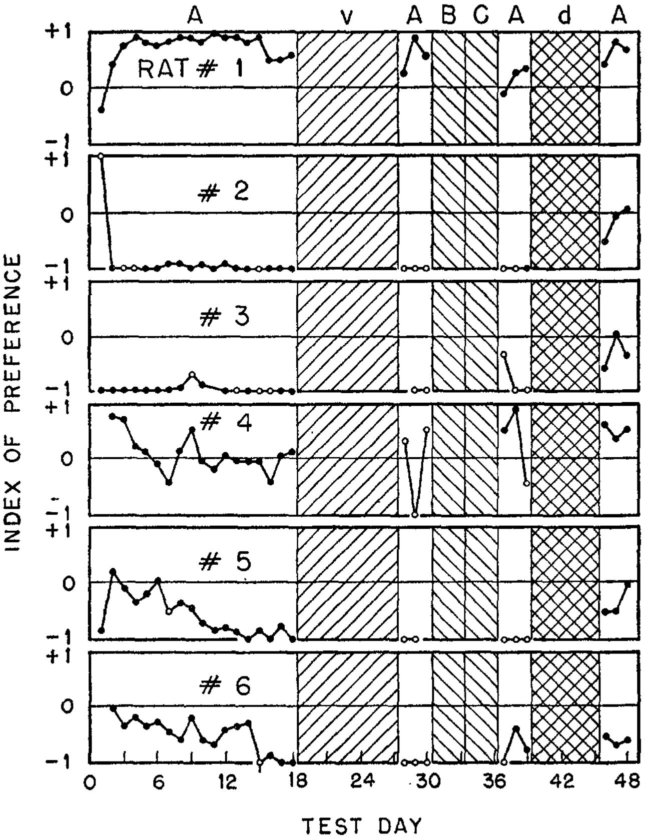

FIG. 2. PREFERENCE FOR PLAIN OR FOIL-COVERED PELLETS

The index of preference is based on the first 25 pellets hoarded (or upon the entire hoard if the rat took fewer than 25). It is positive if the rat favored plain pellets (P), negative if he favored foil-wrapped pellets (F). Index = (P − F)/(P + F). The courses of the daily indexes are shown by the curves. Open circles indicate that fewer than 10 pellets were hoarded. At the top of the graph are letters designating the parts of the experiment according to the key given in table 1.

TOWARD A THEORY OF HOARDING

In our hoarding apparatus, as on Wolfe's (8) and on Bindra's (1, 2) open planks, rats hoarded food without previously having been deprived of it. Most of our rats hoarded foil-covered pellets in preference to plain ones. They hoarded peanuts and candy more actively than ordinary rat food. They hoarded more after deprivation than they did before. What is the significance of these observations for a theory of hoarding?

We believe that, in seeking to understand the onset of hoarding, we should shift our emphasis from the motor to the sensory side of the rat. It now appears most unlikely that hoarding depends upon the triggering of a neural mechanism by rising or falling concentration of a chemical substance in the blood (5, 7). If it did, rats would not hoard foil-covered pellets while refusing to carry plain ones.

A theory of hoarding must take into account the visual characteristics of the objects to be hoarded, perhaps also their tactile characteristics, and certainly their taste. It must also take into account the relation of the animal to the situation in which he finds the objects: familiarity (3), security (1), illumination (6). These factors are sensory or perceptual, and placing emphasis upon them draws our attention away from the gross chemical or hormonal state of the animal. It suggests that we ask whether other factors that affect hoarding—deprivation for example—might not exert their influences primarily *via* perceptual processes. If it should turn out that a rat hoards sour pellets after deprivation in quite the same way as he hoarded sweet pellets before deprivation, we should conclude not that deprivation sets off the behavior, but that it influences the perception of the pellets.

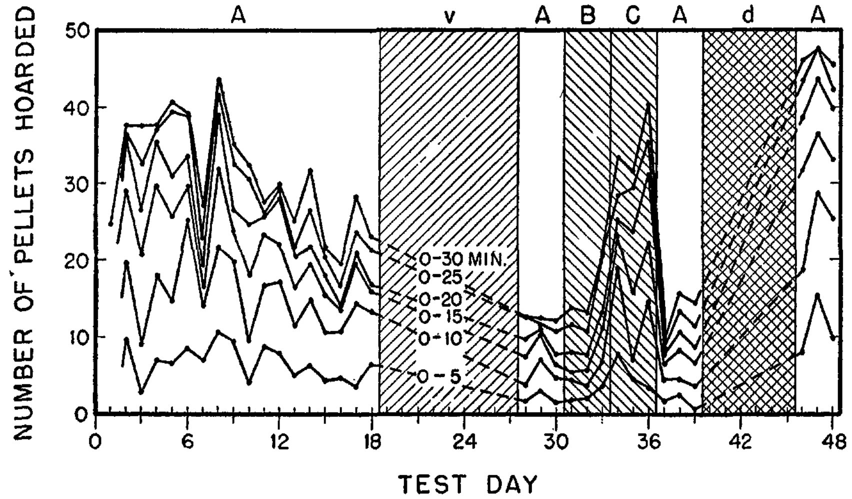

FIG. 3. TEMPORAL COURSE OF HOARDING

The ordinates show the mean number of pellets hoarded, the part of the half-hour test period in which they were hoarded being indicated as the parameter. The letters at the top of the graph are identified in table 1.

We can conceive the perceptual process as dynamic, with the neural representation getting ahead of the actual situation and pulling the rat along, as it were, by setting the orientations and the directions of his motor activities. The motor mechanisms, then, might in turn tend to get ahead of the sensory mechanism when the hoarding activity is in full swing. Something of this latter sort is strongly suggested by the behavior of a rat that has just hoarded the last pellet in the bin: the rat returns to the empty bin, circles it, sniffs in a corner, then dashes for the cage. Half-way up the alley the rat stops, realizing, we might imagine, that it has no pellet after all. The rat comes back once more to the bin, explores, sniffs, chases its tail, then starts off again for the cage without a pellet.

SUMMARY

We observed the behavior of rats hoarding plain and foil-covered pellets of Purina Laboratory Chow in a somewhat unusual hoarding apparatus. The fact that the rats hoarded assiduously even though they had never been deprived of food, the strong preference of some of the rats for pellets wrapped in aluminium foil, and the persistence and stereotypy of the hoarding behavior once it is started, indicate that:

(1) Bindra (1, 2) is entirely correct in saying that deprivation is not a necessary condition for hoarding. Under the conditions of our observations, some of the rats reached a rate of 50 pellets in 15 minutes even though they always had an abundance of food in their cages.

(2) The factors that lead to hoarding and that determine what is hoarded are by no means entirely alimentary. The initiation of hoarding seems to be for the rat, as for the human being, a complex motivational problem to which sensory and perceptual factors, rather than blood chemistry, hold the key.

(3) Once the rat has started hoarding, the motor mechanism becomes partially autonomous—independent to a considerable extent even of the perceptual processes that got it started. As a result, the hoarding behavior-pattern shows marked stereotypy, and the rat sometimes continues to make the circuit from cage to bin to cage after he has taken all the pellets.

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